

HIGH-ENERGY-DENSITY COATING OF HIGH-TEMPERATURE ADVANCED MATERIALS FOR ENERGY-EFFICIENT PERFORMANCE

BENEFITS

- ➔ Through the appropriate selection and control of precursor mixtures and processing parameters (such as continuous wave mode, pulse tailoring technique, beam power, and traverse speed, LPIASM can be tailored to synthesize/fabricate materials in the surface region that are physically and chemically compatible with a wide variety of ceramic or metal substrate systems.
- ➔ The surface modification of industrial components via LPIASM will extend their lifetimes by improving corrosion and wear resistance at the surface.

APPLICATIONS

This coating technology has broad range of applications, such as hydro turbines, heat exchangers, die-casting dies and inserts, continuous steel-casting rolls, transfer rolls for flat glass, cutting and casting tools, combustion chambers in diesel engines, components for chemical processes, components for processing of pulp and paper, and auto engines.

The technique will be employed initially for TiC, TiB₂, and Al₂O₃ coatings and may be further extended to a variety of ceramic systems, including TiN and SiC, Si₃N₄ ceramics on steel, Ti-alloy, and Al-alloy.

The industries impacted by this project include:

- ➔ Agriculture,
- ➔ Aluminum,
- ➔ Chemical,
- ➔ Forest Products,
- ➔ Forging,
- ➔ Glass,
- ➔ Heat Treating,
- ➔ Metalcasting,
- ➔ Mining,
- ➔ Petroleum,
- ➔ Process Heating, and
- ➔ Steel.

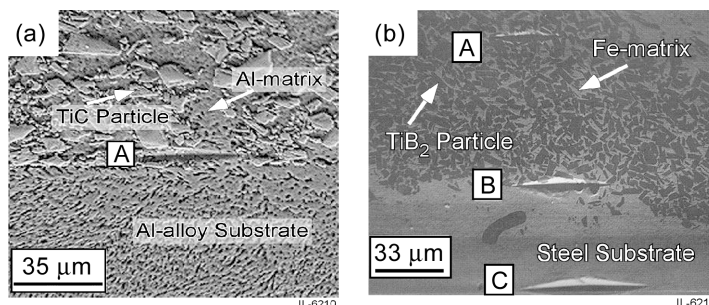


HIGH-ENERGY DEPOSITION TECHNIQUES WILL ENHANCE SURFACE PROPERTIES

The proposed approach, Laser and Plasma Infrared-Assisted Surface Modification (LPIASM), involves synthesis and/or fabrication of the modified surface via chemical, microstructural, and physical transformation in a controlled manner using external heating provided by a high-energy-density laser beam and/or a plasma infrared heat source. Localized heating of the precursor (elemental or alloy or molecular) deposited surface by the laser beam and/or plasma infrared heat source will initiate a chemical transformation, which will further be sustained to synthesize reaction products at the interface between the modified surface region and the substrate, resulting in chemical interaction and bonding. The proposed research is designed to prove the feasibility of the technique for synthesis/fabrication of ceramic, composite, and metal-based modified surface layers on ferrous and nonferrous materials. Unlike many other surface modification techniques, LPIASM offers precise control over processing parameters and thus allows creation of thermal conditions suitable to promote controlled reactions between the substrate material and precursor material to aid in increasing surface energy and wettability of substrates via formation of different products at the interface. Also, the action of a high-energy flux delivered by a laser and/or infrared source at a convenient location eliminates the need to heat a large volume of the material system by an external heat source, thereby avoiding damage to the whole structure. This is particularly useful in critically thin sections or geometries that have complicated topographies.



**LASER COATING OF CERAMIC
ON STEEL MILL ROLL**



Composite coatings produced using the LPIASM technique: (a) TiC/Fe composite coating on 6061 Al-alloy and (b) TiB₂/Al composite coating on 6061 Al-alloy.

(Courtesy of Center of Laser Applications, University of Tennessee. Contact: Prof. Narendra B. Dahotre, ndahotre@utk.edu)

Project Description

Goal: The goal of the project is to develop a reliable, efficient, and economic method of coating ceramic on metal by using a high-energy-density technique. The process and coating-substrate material systems will be optimized to suit specific industrial applications. The goal also includes characterization of processed coating-substrate material systems for wear and corrosion properties under various conditions. The correlation between coating properties and process parameters will be established.

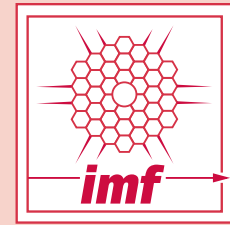
Issues: Applications continue to drive conventional materials to their limits in terms of wear and corrosion. Application of coatings can extend component life extensively, thereby saving energy. The coating technology must be cost effective, reproducible, and industrially robust.

Approach: The major objectives of the research activity are (1) to understand the chemical, physical, and microstructural transformations taking place in the selected representative systems during LPIASM treatment (this knowledge about various transformations is necessary to subsequently develop highly efficient and cost-effective customized applications for surface protection/modification) and (2) to develop a technique for modifying the surfaces of various geometries and materials for enhanced wear and corrosion properties in real components.

Potential payoff: The surface modification of industrial components via LPIASM will extend their life by improving corrosion and wear resistance at the surface. Energy benefits are anticipated through increased lifetime of structural materials, less downtime and maintenance, and more efficient materials processing.

Progress and Milestones

- ➔ Coat low alloy steel with both techniques.
- ➔ Analyze coating results.
- ➔ Measure coating properties.
- ➔ Optimize coating processes.
- ➔ Target application coating.



PRIMARY

University of Tennessee
Knoxville, TN

PROJECT PARTNERS

Applied Thermal Coatings
Chattanooga, TN

Cummins Engine
Columbus, IN

Hydro Resource Solutions
Norris, TN

Oak Ridge National Laboratory
Oak Ridge, TN

Stoody
Bowling Green, KY

Weyerhaeuser
Plymouth, NC

FOR ADDITIONAL INFORMATION, PLEASE CONTACT

EERE Information Center
Phone: (877) 337-3463
Fax: (360) 236-2023
eereic@ee.doe.gov

Visit our home page at
<http://www.eere.energy.gov/industry/>

Office of Industrial Technologies
Energy Efficiency
And Renewable Energy
U.S. Department of Energy
Washington, DC 20585
<http://www.oit.doe.gov>



January 2002